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CARBON MATERIALS FOR ELECTRICALLY CONDUCTIVE CONCRETE

Savytskyi M.[1], Prof., Dr. Sc. (Tech.), **Sukhyy K.**[2], Dr. Sc. (Tech.),
Shevchenko T.[3], PhD, Assoc. Prof., **Marchenko I.**[4], Eng., **Lyasota O.**[5], PhD Stud.
[1, 2] Ukrainian State University of Science and Technologies,
[3, 4, 5] Prydniprovska State Academy of Civil Engineering and Architecture
[1]ms@pdaba.edu.ua; [2] k.m.sukhyi@ust.edu.ua;
[3] shevchenko.tetyana@pdaba.edu.ua; [4] igor.a.marchenko1976@gmail.com;
[5] liasota.oleksandr@pdaba.edu.ua

Problem statement. Electrically conductive concrete [1] is a promising direction in the creation of smart concrete. In this case, they can act as generators of electrical energy, heat energy, accumulators of electricity, elements of protection against electromagnetic fields.

The mechanism of electrical conductivity in composite electrically conductive materials is quite complex. In the simplest case, charge transfer can occur through direct contact between aggregate particles. Therefore, electrically conductive concrete must contain an electrically conductive aggregate. Electrically conductive aggregates can be combined into two main groups: a) metal; b) carbon [2].

One of the most important criteria for the filler of electrically conductive composites is availability and low cost. Therefore, it is advisable to use inexpensive electrically conductive fillers. These conditions are most fully satisfied by carbon fillers. Carbon, like a metal, has electronic conductivity. Carbon fillers include soot, graphite, carbon black, coke. These fillers are cheap, available in any region, and have low electrical resistivity. Currently, there is no generally accepted method for determining the electrical resistivity of electrically conductive fillers, so its development and testing is necessary.

Purpose of the study. The purpose of this research is to create a method for determining the resistivity of electrically conductive fillers, test the technique and experimentally determine the electrical resistivity of some carbon fillers for electrically conductive concrete.

Maine results. The essence of the method for measuring the electrophysical parameters of electrically conductive fillers is to measure the resistance of a filler column enclosed in a dielectric tubular matrix between two conductive punches under a pressure of 1 MPa with the passage of direct current.

Equipment. To carry out measurements, the following are used: 1) a direct current source − charger, adapter or battery; 2) multimeter for measuring electrical voltage, multimeter for measuring electric current; 3) laboratory press providing a pressure of 1 MPa; 4) a matrix with punches to which electrical conductors are connected.

Testing. A sample of electrically conductive material is loaded evenly into a matrix with a lower punch. The upper punch is inserted into the matrix with electrically conductive material. The matrix with punches and insulating gaskets is inserted into the press. Press loading is carried out with a force that provides a pressure of 1 MPa on the material. After 1 minute after loading, the punches are connected to the measuring circuit. The measurement is repeated for three samples of the same batch of electrically conductive material.

Processing the results. The value of conductor resistance can be determined using the formula of Ohm's law:

$$R = U/I, \qquad (1)$$

where: R − resistance in ohms, Ω; U − voltage in volts, V; I − electric current in amperes, A.

It was experimentally discovered that the resistance value of any conductor is directly proportional to its length and inversely proportional to its cross-sectional area. In other words, the longer the conductor and the smaller its thickness, the greater the resistance of the conductor. In formula form it looks like this:

$$R = \rho * L/A, \quad (2)$$

where: L − length, m; A − cross-sectional area, m^2; ρ − resistivity, Ohm m.

$$p = R * A/L. \quad (3)$$

The final resistivity result is taken as the arithmetic mean of all measurements.

For testing, we used coke breeze [3] with a maximum grain size of 5 mm and carbon black [4] (Fig. 1).

A polypropylene pipe 260 mm long with an internal diameter of 23 mm was used as a matrix. A screw press equipped with a dynamometer was used as a loading device.

A battery charger and a rechargeable battery were used as a current source.

A multimeter for measuring electrical voltage and a multimeter for measuring electric current were used (Fig. 2).

a *b*

Fig. 1. Electrically conductive material for testing: a) carbon black; b) coke breeze

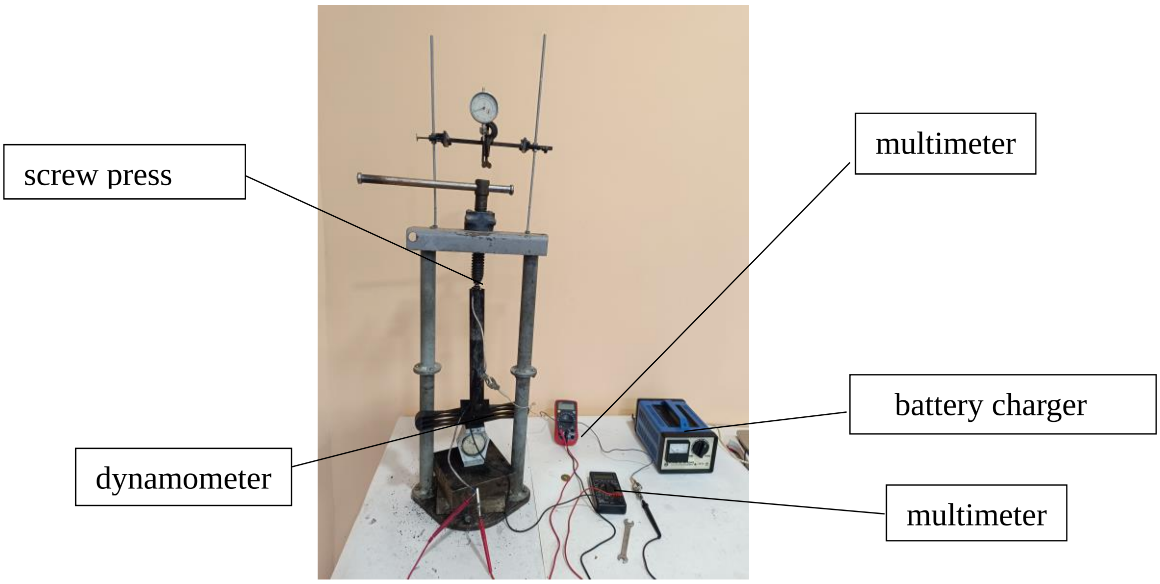

Fig. 2. Equipments for testing the electrical resistivity of electrically conductive fillers

The results of tests performed to determine the electrical resistivity of electrically conductive fillers are shown in the Table 1 and Table 2.

Table 1

The testing results the of coke breeze electrical resistivity

Specimen	Temperature, ºC	Current, mA	Voltage, V	Moving/ length, mm	Resistance, Ohm	Resistivity, Ohm*m
Charging device						
1	18	7,64	13,06	4−246	1 709	2,88
2	18	7,49	12,94	7,7−242,3	1 727	2,96
3	18	7,58	12,28	7,6−242,4	1 620	2,77
Accumulator battery						
1	18	8,59	12,75	8,1−241,9	1 484	2,54
2	19	8,84	12,69	7,1−242,9	1 436	2,45
3	22	7,84	12,73	9,5−240,5	1 624	2,80
Average value						**2,73**

Table 2

The testing results the of carbon black electrical resistivity

Specimen	Temperature, ºC	Current, mA	Voltage, V	Moving/ length, mm	Resistance, Ohm	Resistivity, Ohm*m
Charging device						
1	18	3,06	13,06	26,1/224	4 268	7,90
2	18	3,71	12,94	22,0/228	3 488	6,35
3	18	3,11	13,10	24,0/226	4 212	7,73
Accumulator battery						
1	18	3,33	12,86	22,8/227,2	3 862	7,05
2	18	3,11	12,92	21,5/228,5	4 154	7,54
3	18	3,40	12,90	24,2/225,8	3 794	6,97
Average value						**7,26**

Conclusion. 1) A methodology for determining the conductive characteristics, namely, the resistivity of bulk materials for the production of conductive concrete, has been developed.

2) Tests were carried out and data on the resistivity of carbon black (7,26 Ohm*m) and coke breeze (2,73 Ohm*m) were obtained.

3) The obtained results prove that the conductive properties of coke breeze are 2.7 times higher than those of carbon black.

References

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